Rymer, Edwina

From: Bates, William
Sent: Wednesday, March 04, 2015 11:06 AM
To: Dellinger, Philip
Subject: RE: Dallas Morning News - Sunday, March 1, 2015 - Oil & Gas Drilling and quakes

Thanks Phil!

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From: Dellinger, Philip
Sent: Wednesday, March 04, 2015 10:31 AM
To: Bates, William
Subject: FW: Dallas Morning News - Sunday, March 1, 2015 - Oil & Gas Drilling and quakes

Nice job Bill.

From: Lawrence, Rob
Sent: Tuesday, March 03, 2015 5:04 PM
To: Overbay, Michael; Casso, Ruben; Dellinger, Philip; Dorsey, Nancy; Hanley, Mary; Hanson, Andrew; Bates, William; Beeler, Cindy; Card, Joan
Subject: Dallas Morning News - Sunday, March 1, 2015 - Oil & Gas Drilling and quakes

Experts looking for middle ground in earthquake-fracking debate

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File 2013/The Plain Dealer

Ohio is one of three states with a network of seismometers that can pick up very small earthquakes before they cause damage, such as the quakes that struck under this well near Youngstown. Among the network's advantages is that it can help geologists locate earthquakes more accurately and determine whether there is a natural fault near a disposal well.

By ANNA KUCHMENT
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Since earthquakes began rattling North Texas in 2008, some residents have reacted with anger and others with a shrug.

In Irving, where on Friday a magnitude 3.1 earthquake hit, one of nearly 50 since April, some residents have called for a ban on hydraulic fracturing, which creates large volumes of wastewater that companies inject deep into the ground. Scientists have linked injection wells to two of the four earthquake clusters that have shaken the Dallas-Fort Worth area.

Others have insisted that the occasional lurch in the Earth's crust is a small price to pay for American energy independence.

Researchers are slowly homing in on a middle ground: They are investigating ways to prevent wells from causing damaging earthquakes without hindering most oil and gas operations.

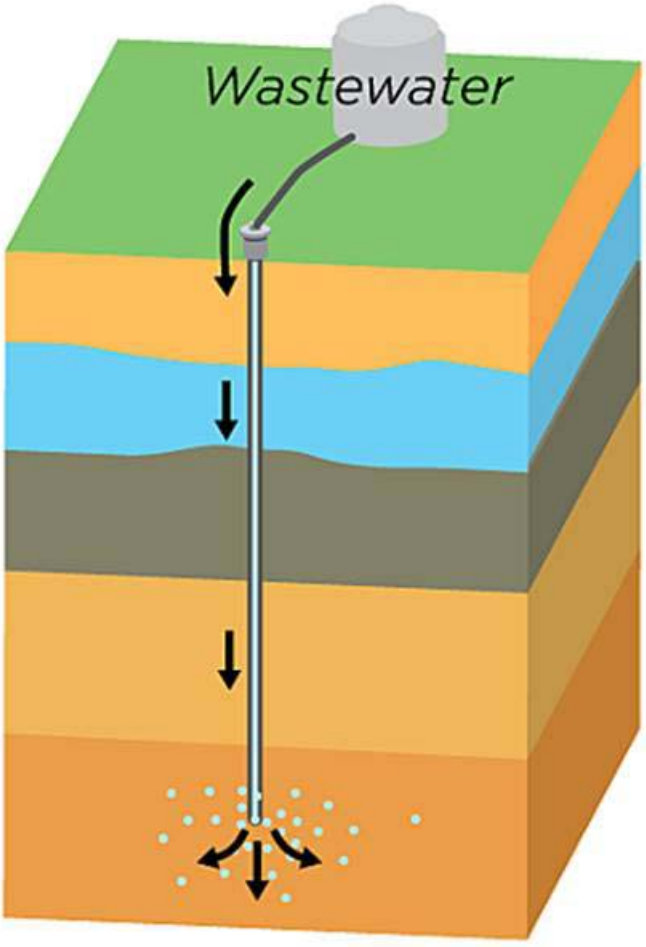
The proposals include mapping potentially dangerous faults before injection operations begin; detecting small earthquakes to determine whether they herald larger ones; "fingerprinting" quakes to help more quickly identify their cause; and keeping close tabs on the volume of fluid injected into wells and on the underground pressure near injection zones.

"I really think bans on hydraulic fracturing are political statements rather than risk management tools," said Mark Zoback, a geophysics professor at Stanford University and co-director of the Stanford Center for Induced and Triggered Seismicity, which collaborates with and receives funding from the oil and gas industry.

The fluid factor

Wastewater from hydraulic fracturing operatic
earthquakes when injected into underground

❶ Fluid from the fracking process is disposed of by injecting it deep underground into porous rock formations.



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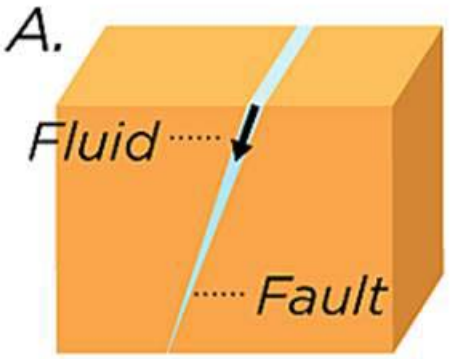

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Asked about these proposals for reducing earthquake risk, Ramona Nye, a spokeswoman for the Railroad Commission of Texas, which regulates the oil and gas industry, said there were no definitive links between oil and gas activity and earthquakes in the state.

She added, “The geology in Texas is different from the geology in other states, so there is no one-size-fits-all recommendation.”

Under pressure

At the heart of the research is an improved understanding of how injecting fluids into the Earth can, in rare cases, cause the ground to shake.

The central U.S., like just about every part of the globe, is littered with faults. The vast majority have never been mapped.

While most are dormant, they lie in a constant state of stress as tectonic plates shift around them.

Much of that stress is released at the San Andreas fault, where the North American plate and the Pacific plate collide. But some of the energy reverberates into the middle of the continent, where it squeezes the rocks beneath Oklahoma, Texas and other central states.

While few faults are under enough stress to rupture on their own, it can take only the tiniest of disturbances to set some of them off. That is what scientists believe happens in cases of human-induced tremors.

If fluid from an injection well infiltrates a fault, the pressure from that fluid can be enough to trigger an earthquake.

Needles in a haystack

The key is to figure out which fractures are susceptible to human-induced pressure and which ones are not.

That distinction comes down to how faults are positioned with respect to the natural geologic stress in their region.

“It’s only those faults that are properly oriented in today’s stress field that will be likely to slip,” said Bill Ellsworth, a seismologist with the U.S. Geological Survey.

To illustrate the difference between a potentially active fault and a dormant one, Ellsworth uses the example of a brick sitting on a table. Push down on the brick from above, and it won’t budge. Push it from the side, and it will slip against the table.

Zoback of Stanford is working on a way of predicting which faults hold the potential to slip as a result of industrial activity. Using data that oil and gas companies gather as they drill, Zoback and his

colleagues have been studying the stress field in Oklahoma and comparing it to the orientation of faults across the state.

“The goal is to identify and avoid potentially active faults during wastewater injection,” Zoback said.

He and his collaborators are now exploring the possibility of extending that work to Texas. “The idea really is to take this pilot study and apply it elsewhere where there is concern about induced and triggered seismicity,” he said.

Quake catchers

Zoback said his method isn’t foolproof. Even the most thorough mapping effort can miss a potentially active fault. He suggests pairing his mapping technique with a network of seismometers that can pick up very small earthquakes before they cause damage.

“Careful seismic monitoring is about the best answer we can come up with at this stage,” said Art McGarr of the USGS and lead author of a recent paper in the journal *Science* on earthquakes and wastewater injection wells.

Oklahoma, Ohio and Colorado are among the states that have such networks in place.

Among the advantages of having such a network is that it can help geologists locate earthquakes more accurately and determine whether there is a natural fault near a disposal well. Fault mapping also allows scientists to determine a fault’s size and to predict the maximum magnitude earthquake it is capable of producing.

Texas has 16 permanent seismic stations. They can detect earthquakes down to magnitude 3.0 and can locate them with an accuracy of plus or minus 6 miles.

“That’s not nearly good enough,” said McGarr, speaking generally of how accurate a seismic network should be to allow scientists to locate earthquakes. The denser the network, the greater its level of precision and sensitivity.

Texas does have a seismic network in the works. Included in a 2016-17 state budget proposal is nearly $2.5 million in funding for TexNet, which includes an additional 22 permanent seismic monitors, plus 36 portable stations that could be deployed if scientists suspect that human activities are inducing tremors.

The new stations would enable Texas geologists to detect quakes down to magnitude 2.0 and would double location accuracy, said Scott Tinker, state geologist of Texas and director of the University of Texas at Austin’s Bureau of Economic Geology, which would manage the project.

Such networks could also be part of “traffic light” systems that have been deployed in Ohio, Colorado, Oklahoma and the United Kingdom.

In Ohio, if earthquakes reach magnitude 2.0, and regulators suspect they may be linked to industrial activity, the Ohio Department of Natural Resources temporarily shuts down nearby wells pending an investigation. After a well reopens, a follow-up earthquake with a magnitude as low as 1.0 is enough to trigger a second shutdown, said Eric Heis, a department spokesman.

Quake ‘fingerprints’

Seismic networks can also help scientists zero in on an earthquake’s cause. Mike Brudzinski, a seismologist at Ohio’s Miami University, used a technique that he compares to fingerprint matching to help link 77 earthquakes near Lowellville, Ohio, to fracking.

Man-made earthquakes in Ohio have had a specific signature, he said. Natural earthquakes tend to begin at a higher magnitude and be followed by weaker aftershocks over a brief period of time.

“What we’re finding with these induced cases is almost the opposite,” said Brudzinski. “You often start with smaller quakes, then they tend to increase in rate and magnitude.”

For his study, Brudzinski used a regional seismic network in and around Ohio to match ongoing earthquakes with similar ones that had occurred in the past and saw that a suspicious swarm pattern emerged.

Brian Stump, an SMU seismologist who has investigated each of North Texas’ earthquake swarms, said Brudzinski’s approach has been useful in Ohio but needs more research before it can be applied elsewhere.

Pressure monitoring

In a report released last month, the U.S. Environmental Protection Agency recommended keeping tabs on injection volumes and underground pressure near wells as another way of preventing tremors.

“It’s one of many factors you can look at to understand if an earthquake can be induced,” said Bill Bates, an EPA geologist.

Companies or regulators would check an area’s baseline pressure before beginning wastewater injections. If that pressure begins to rise above the baseline, it could be a sign that the injected fluid is building up along a fault.

“If there’s a fault relatively nearby that’s oriented in the right direction, it could tip the scale to allow that fault to slip,” said Bates.

Lack of data

Scientists are only beginning to understand how best to reduce the risk of oil- and gas-related earthquakes.

Gail Atkinson, an expert on earthquake hazards at Western University in Ontario, said progress would move faster if more data could be made publicly available. She suggests asking energy companies to sponsor one earthquake monitor for every 10 wells they install and to make that seismic data widely accessible.

“If that basic data was made available in a format the scientists could use, we could get a long ways on this problem very quickly compared to what we are doing now,” she said.

Ellsworth points out that scientists are heavily invested in the problem and that more solutions should be coming soon.

“The public should feel encouraged to know that there’s a lot of people working on this. We care about it, and we’re pursuing it,” he said. “We may not have the answer overnight, but we’re trying to address the key issues.”

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